AFRL

Characterization of Impact Induced Reaction of Explosives Using the AFRL High Explosive Survivability Test (HEST)

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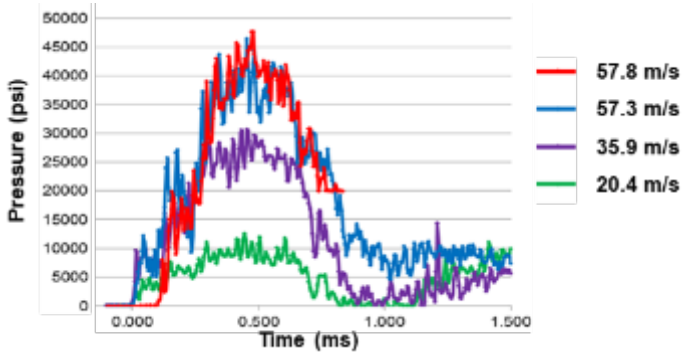
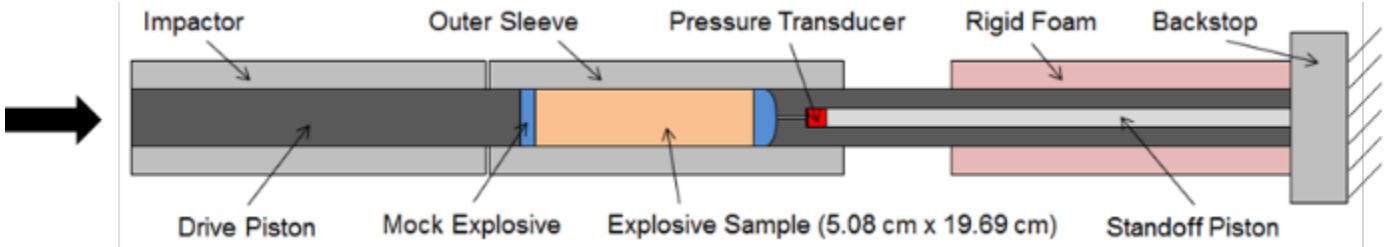
High Explosive Survivability Test (HEST)

- Measure the propensity of an explosive to yield reaction (*deflagration*) under complex (*pressure and shear*) impact loading conditions at lab scale.
- Comparable to Steven Test or Navy Setback Simulator
  - ❑ Designed for “longer” time pressure, larger charge mass (~2 lbs.), and controllable shear/friction on explosive charge
  - ❑ Idealized loading conditions on charge to aid modeling of stress conditions
- Utilize high speed videography to observe occurrence of reaction and motion of hardware
- Vary impact conditions to identify threshold of explosive material following Neyer D-Optimal Sensitivity Test
- Measured pressure pulse and M&S to estimate loading conditions of materials
  - ❑ Allows for filter or ordering system of proposed explosives

High Explosive Survivability Test (HEST)



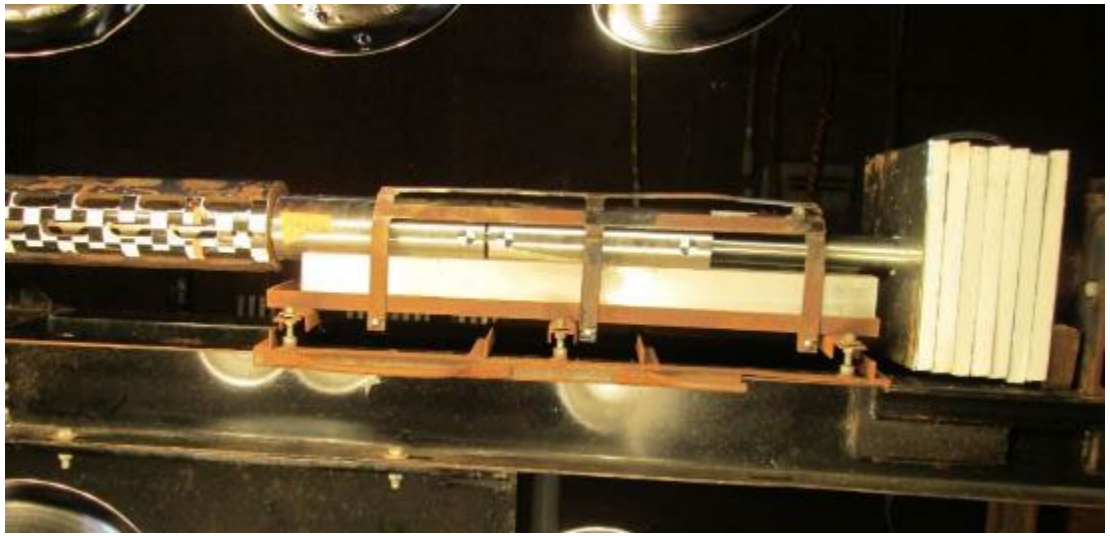
Example of long time pressure pulse in HEST



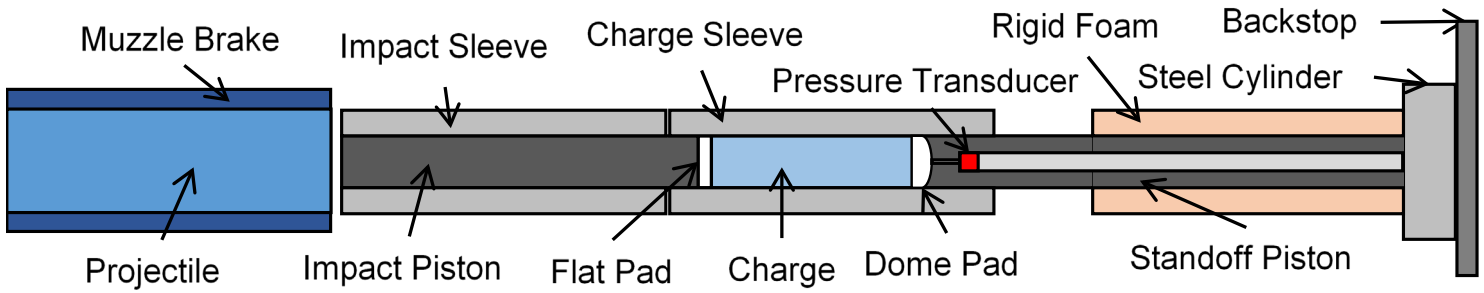
Dynamic loading mechanisms of charge in HEST

High Explosive Survivability Test (HEST)

HEST gas gun



HEST test assembly



HEST assembly diagram cutaway

Typical “GO” result

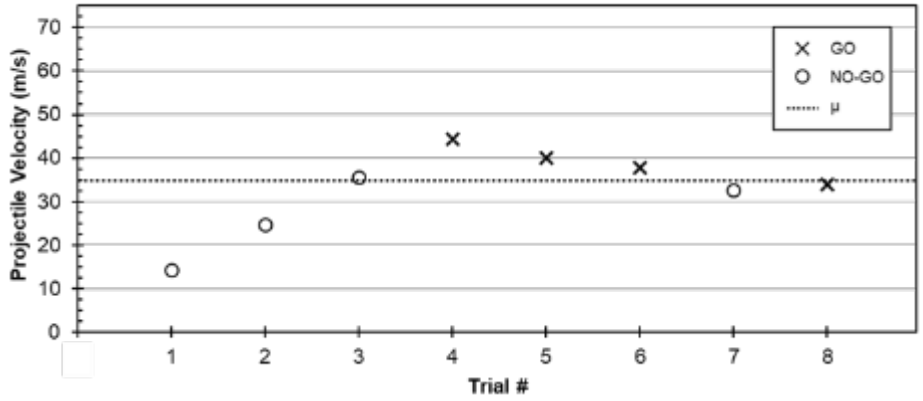
Typical “NO-GO” result

High Explosive Survivability Test (HEST)

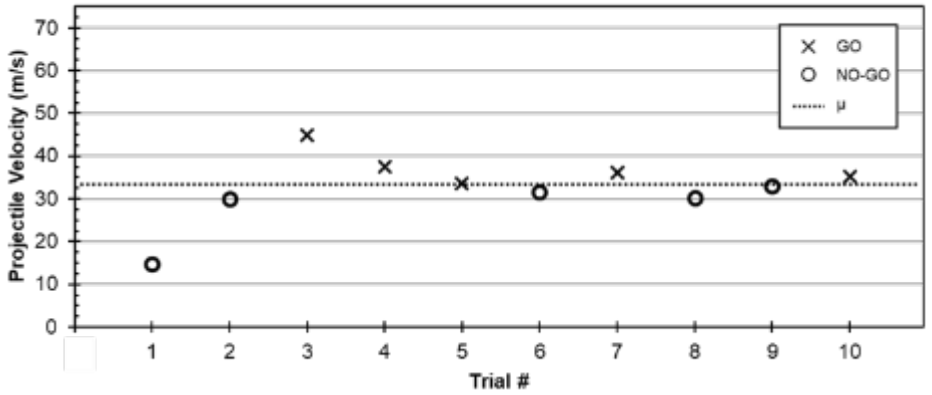
Initial Test Series

- Two test series (Material A and Material B) have been conducted since implemented changes:
  - (1) Switch to Teflon pads
    - Overfit pads (2.020” diameter)
  - (2) Ensure no adhesion at explosive-wall interface
    - Fit slip charge, use of lubricant at wall

Material	Projectile Velocity (m/s)	Result	Observed Reaction Type	% Mass Recovered	Friction Coefficient
Material A	14.38	No-Go	None	-	0.050
Material A	24.72	No-Go	None	100%	0.025
Material A	35.67	No-Go	None	100%	0.025
Material A	44.43	Go	Vigorous	87%	0.025
Material A	40.11	Go	Full Burn	-	0.025
Material A	37.73	Go	Vigorous	79%	0.025
Material A	32.70	No-Go	None	100%	0.025
Material A	33.97	Go	Mild	100%	0.010
Material B	14.67	No-Go	None	100%	0.100
Material B	29.94	No-Go	None	100%	0.010
Material B	44.84	Go	Vigorous	98%	0.010
Material B	37.44	Go	Mild	100%	-
Material B	33.61	Go	Mild	100%	0.010
Material B	31.71	No-Go	None	100%	0.010
Material B	36.04	Go	Full Burn	21%	0.010
Material B	30.25	No-Go	None	100%	0.010
Material B	32.93	No-Go	None	100%	0.025
Material B	35.30	Go	Full Burn	11%	0.025



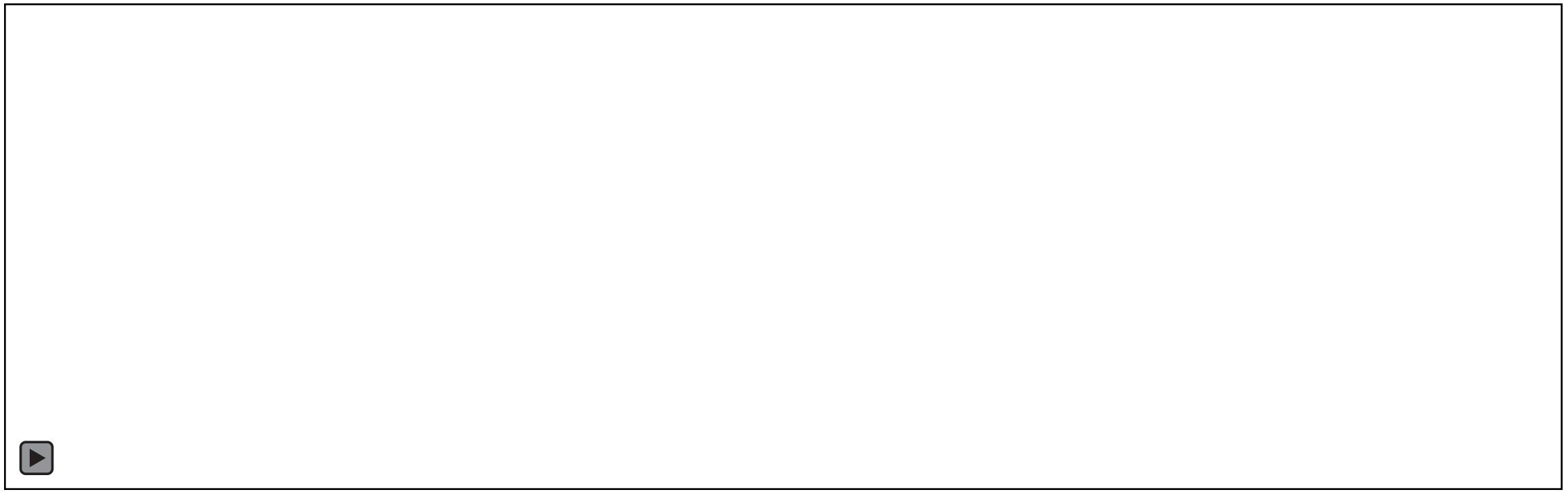
Material A



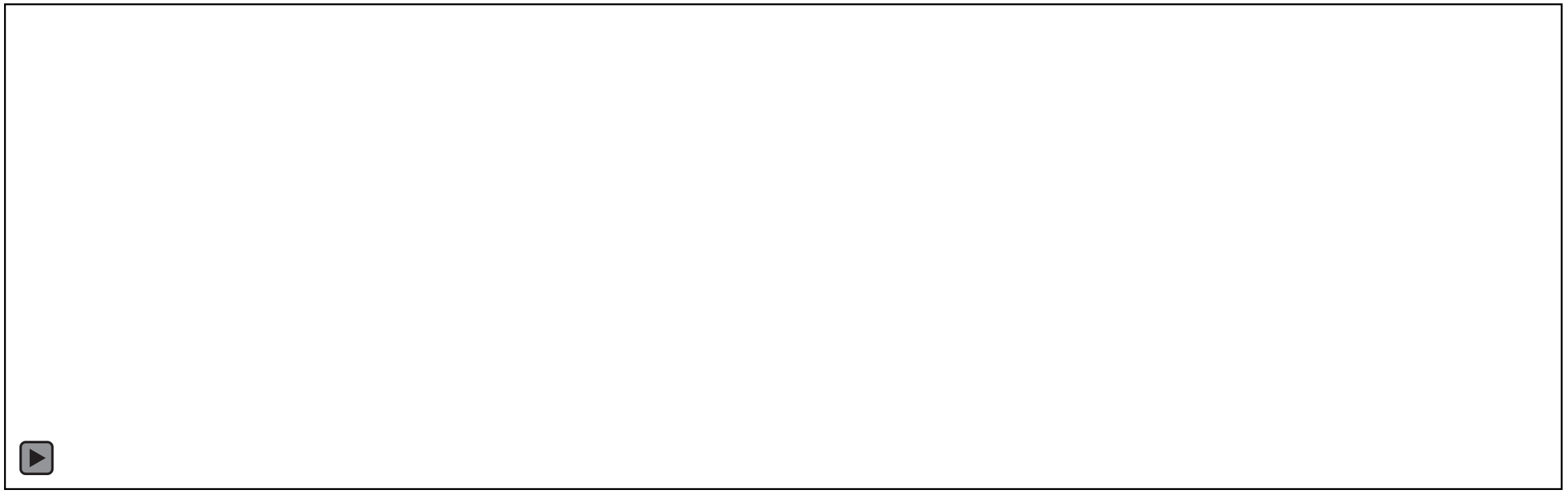
Material B

Explosive	μ (m/s)	σ (m/s)
Material A	34.90	2.56
Material B	33.27	0.68

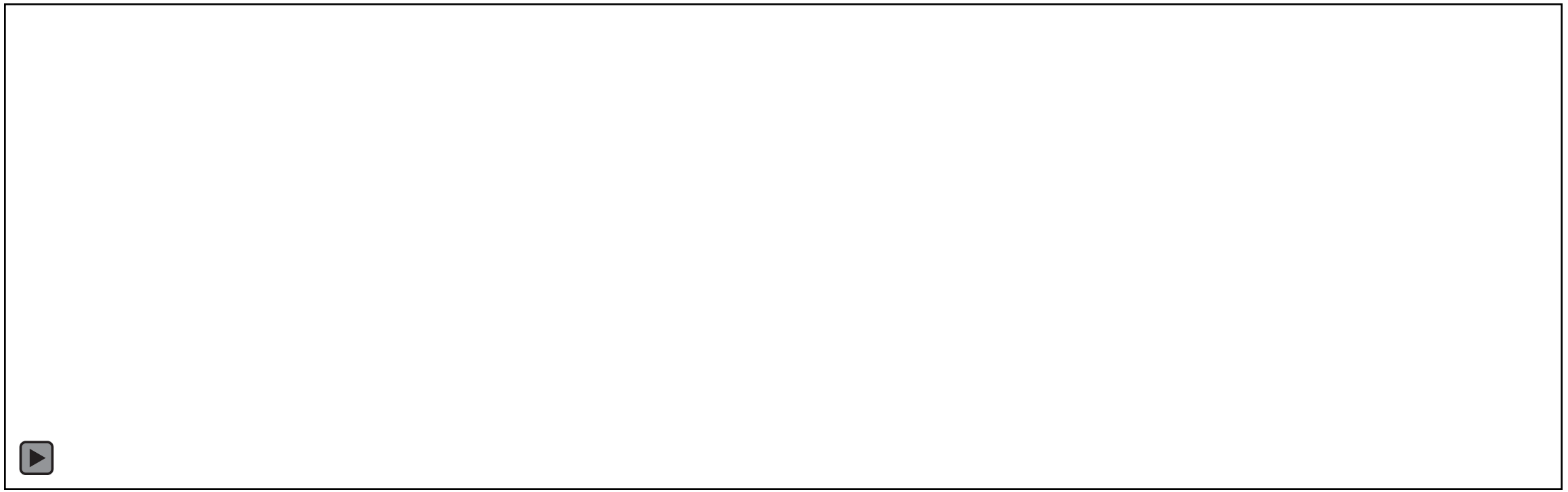
Example of No-Go



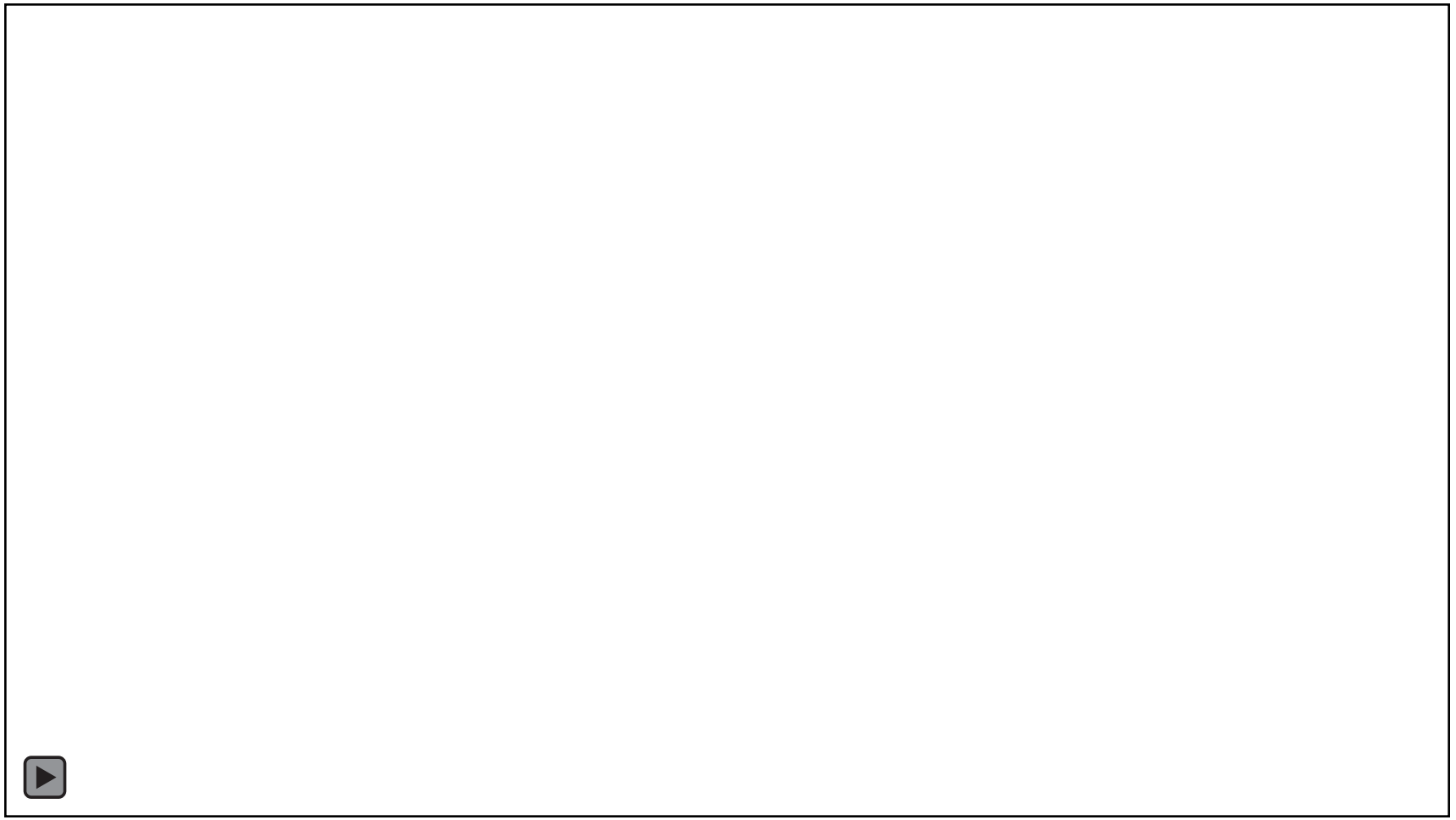
Example of Go (Mild Reaction)



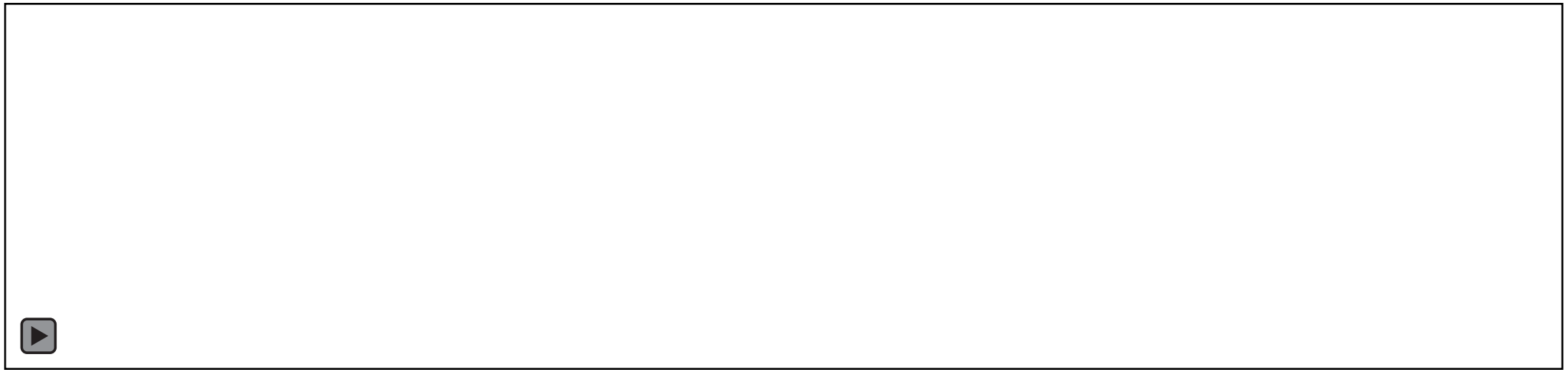
Example of Go (Full Burn)



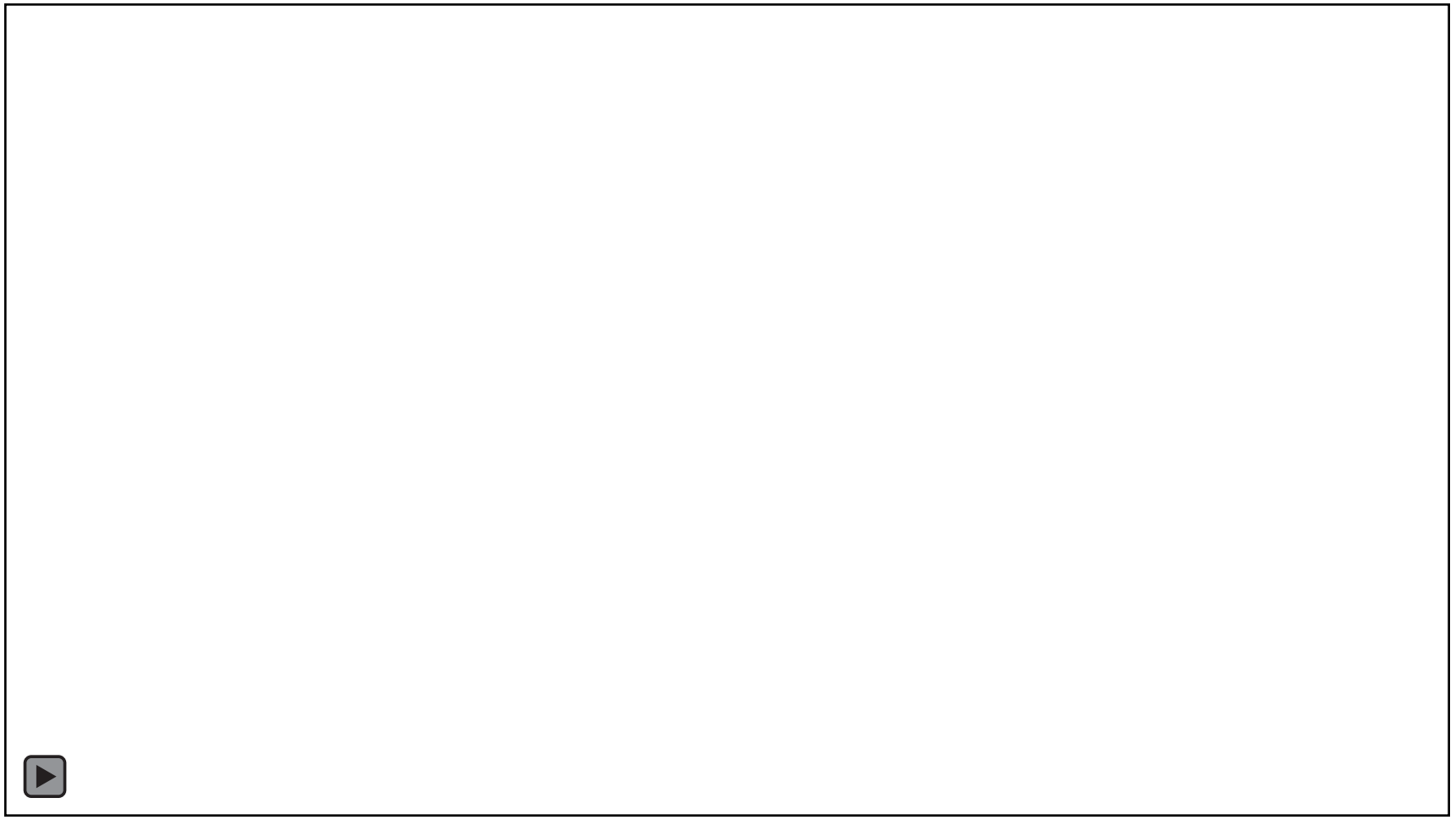
Example of Go (Full Burn) – Chamber View



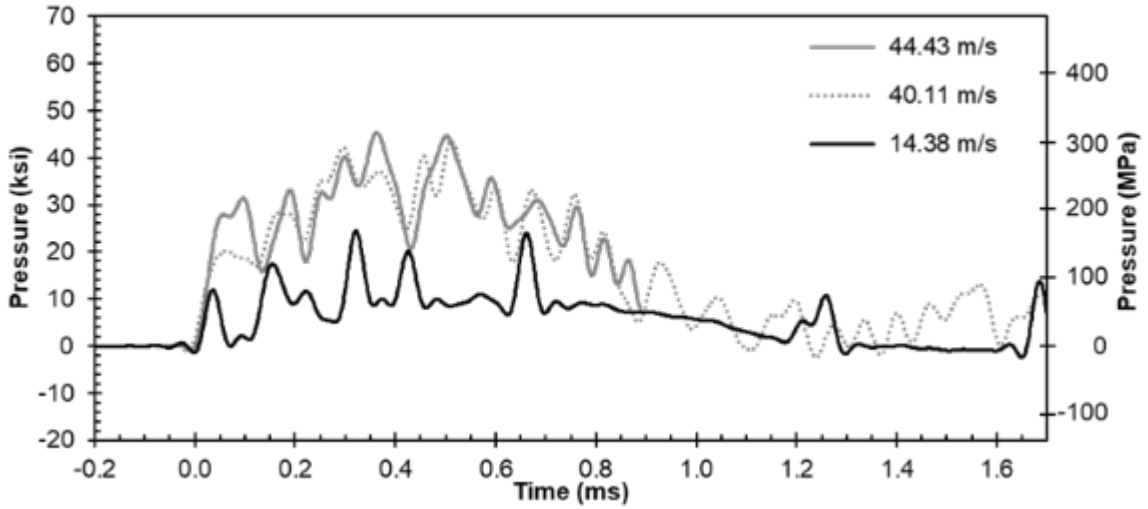
Example of Go (Vigorous)



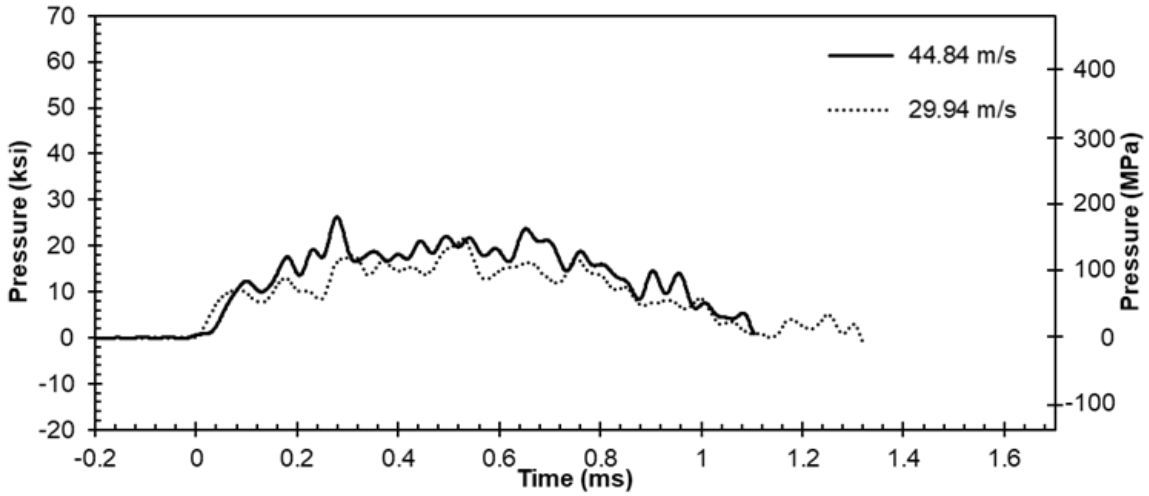
Example of Go (Vigorous) – Chamber View



Diagnostics: pressure measurement



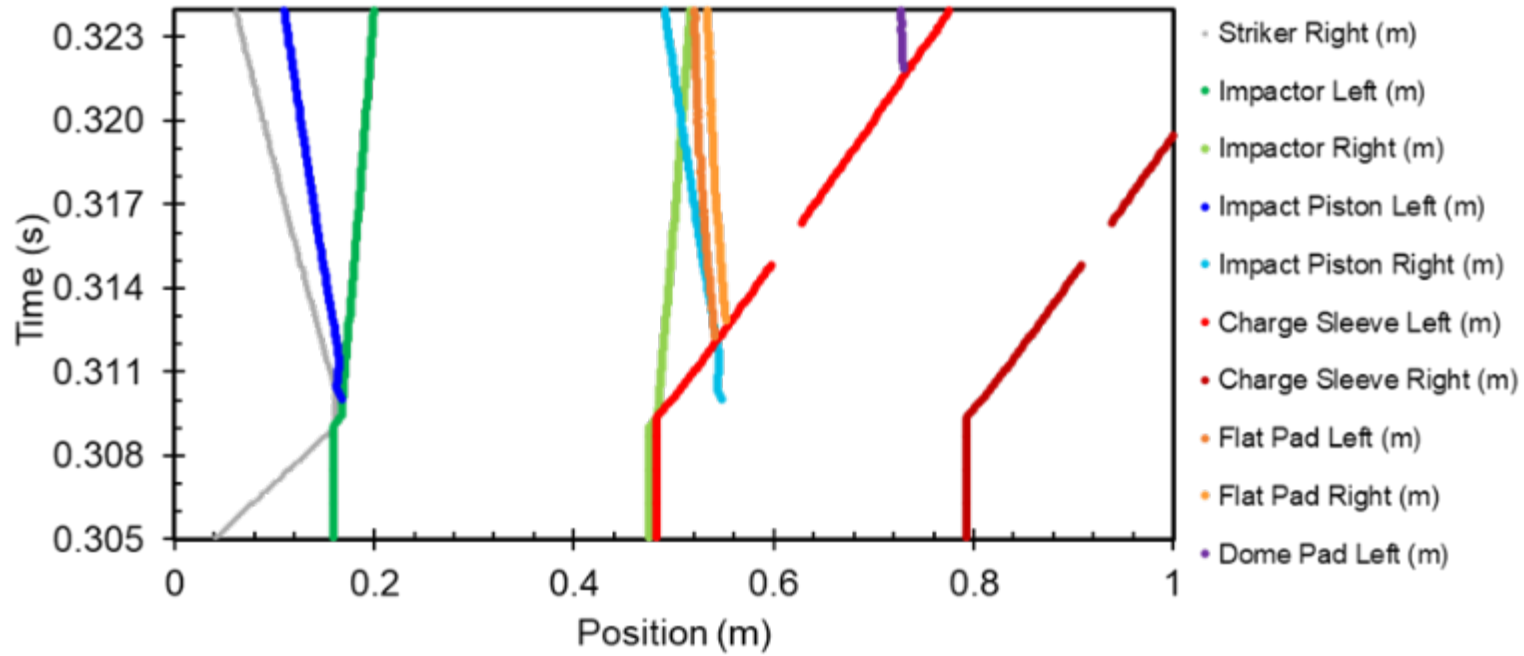
Dynamic pressure measurement for material A



Dynamic pressure measurement for material B

- Poor probability for successful pressure measurement

Diagnostics: *x-t* diagram

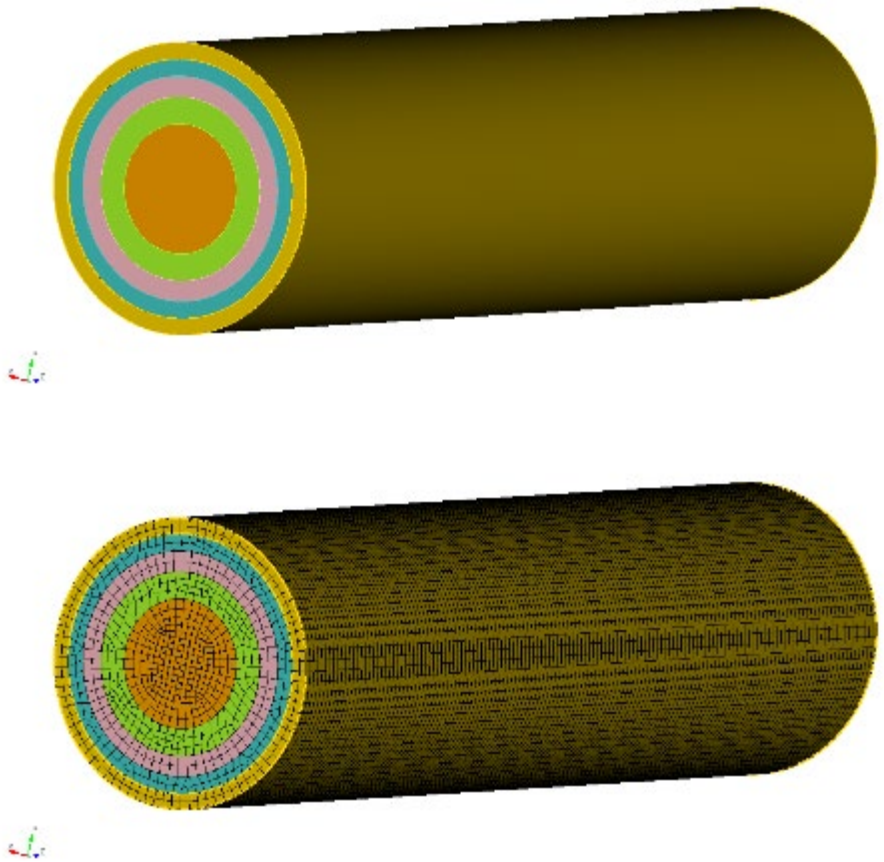


***x-t* diagram information of moving hardware and charge**

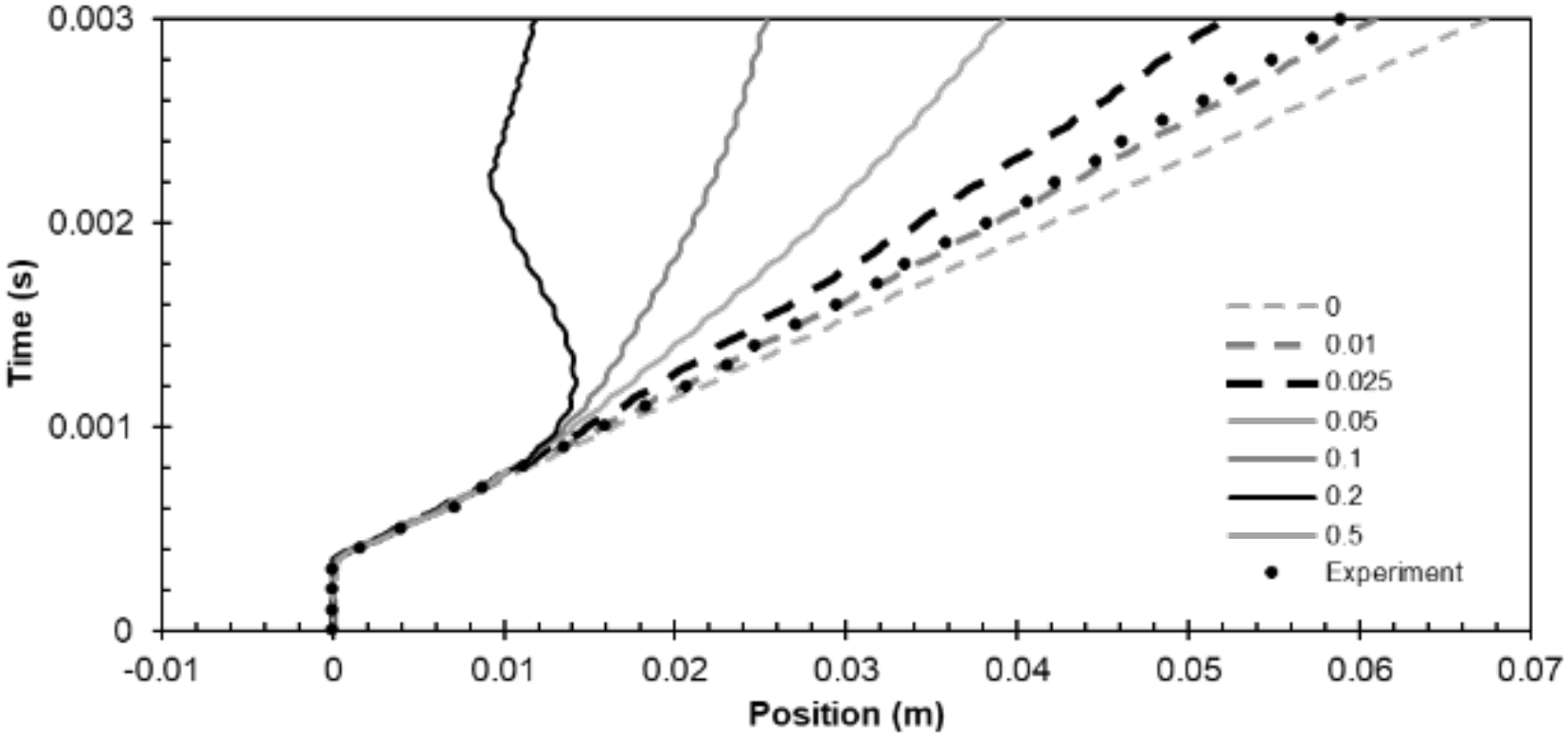
Simulations

Simulations were run using SIERRA Solid Mechanics code version 5.2

- Computational mesh of 275,006 8-noded hex elements
- HE modeled with 127,127 hex elements of equi-weighted concentric rings
- Mechanical model for HE was Simplified Potential Energy Clock (SPEC) model
  - Required shear and bulk thermal and mechanical viscoelastic data
  - Supported by DMA, TMA, Tri-ax measurements
  - Bulk modulus assumed to be constant



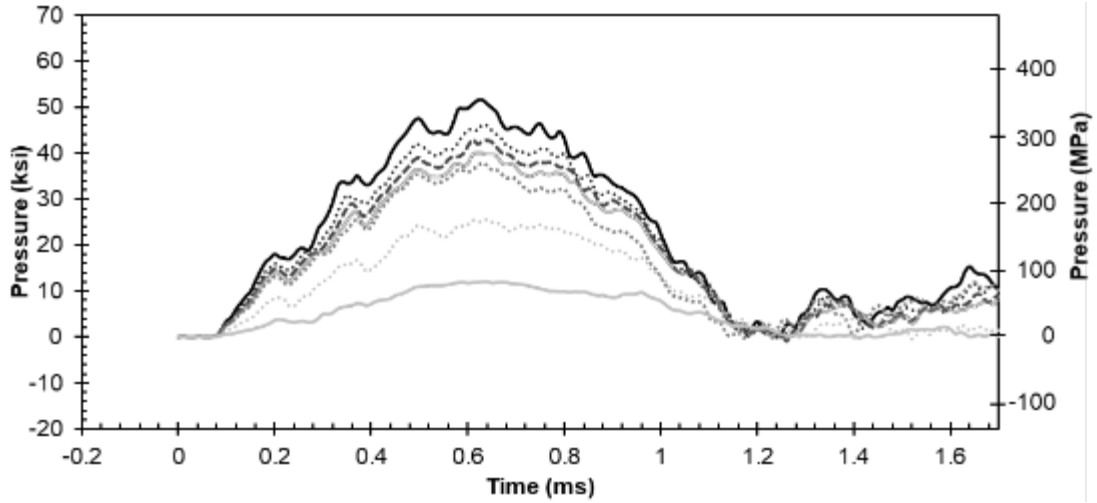
Simulations: friction study



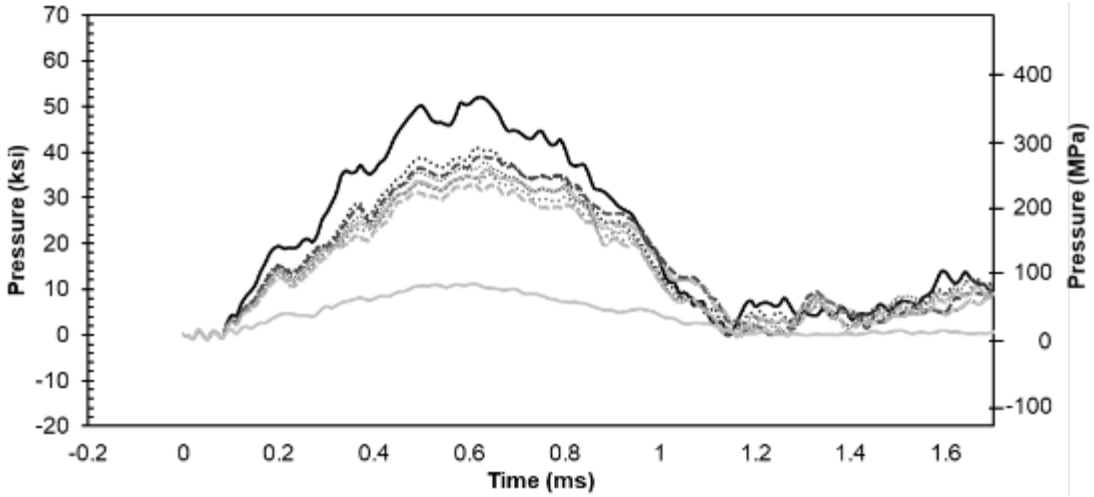
- Varied friction between HE and wall to determine *position data of charge sleeve*

- Effect of bulk modulus had little effect *on charge sleeve position*
- Effect of friction for Teflon pads had little effect *on charge sleeve position*

Simulations: predicted pressure history



Predicted mean pressure histories for material A



Predicted mean pressure histories for material B

Future Work

(1) Investigate the predicted stress distribution over time to better determine stress history required for reaction
- Leading into deflagration prediction modeling

(2) Investigate role of adhesion at the wall on complex loading behavior and resulting impact sensitivity
- Tearing/High Friction/Frictionless
- Different material may be more resilient to different ignition mechanisms

(3) Additional materials

Questions?